

## CLAIMS

What is claimed is:

1. A refrigerator having a compressor for compressing a coolant, a radiator for radiating heat from the coolant, a flow control valve for regulating the flow volume of the coolant, and an evaporator for evaporating the coolant, characterized in that the refrigerator includes:

a coolant cooling means for cooling the coolant; and

a heat-exchange-amount control means for controlling the amount of heat exchanged in the coolant cooling means; wherein

the coolant is circulated through the compressor, the radiator, the coolant cooling means, the flow control valve, and the evaporator, in that sequence.

2. A refrigerator as recited in claim 1, utilizing a nonflammable coolant whose global warming potential is lower than that of chlorofluorocarbon, wherein the coolant cooling means includes:

a second compressor for compressing a second coolant whose energy consumption efficiency is higher than that of the coolant;

a condenser for radiating heat from the second coolant;

a second flow control valve for regulating the flow volume of the second coolant; and

a second evaporator for evaporating, by means of heat from the coolant, the second coolant; wherein

the second coolant is circulated through the second compressor, the condenser, the second flow control valve, and the second evaporator, in that sequence.

3. A refrigerator as recited in claim 1, the compressor having an intermediary-pressure inlet for drawing in the coolant during compressing, the refrigerator further comprising:

a gas-liquid separator for separating into gas and liquid the coolant as

1     outputted from the flow control valve;

2             a bypass pipe for introducing into the intermediary-pressure inlet part or all of  
3     the coolant gas separated by the gas-liquid separator; and

4             a third flow control valve for regulating the flow volume of the coolant as  
5     outputted from the gas-liquid separator and inputted into the evaporator.

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7     4. A refrigerator as recited in claim 1, further comprising:

8             a third compressor for compressing the coolant as compressed by the  
9     compressor;

10            a gas-liquid separator for separating into gas and liquid the coolant as  
11     outputted from the flow control valve;

12            a bypass pipe for introducing into the third compressor part or all of the  
13     coolant gas separated by the gas-liquid separator; and

14            a third flow control valve for regulating the flow volume of the coolant as  
15     outputted from the gas-liquid separator and inputted into the evaporator; wherein

16            the coolant as outputted from the third compressor is inputted into the  
17     radiator.

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19     5. A refrigerator as recited in claim 1, further comprising:

20            a third radiator for radiating heat from the coolant as outputted from the  
21     compressor; and

22            a third compressor for compressing the coolant in a state in which heat of the  
23     coolant has been radiated away by the third radiator; wherein

24            the coolant is flowed through the third radiator, the third compressor, and the  
25     radiator, in that sequence.

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27     6. A refrigerator as recited in claim 2, further comprising:

28            a third compressor for compressing the coolant as compressed by the  
29     compressor; and

30            a third heat exchanger for exchanging heat between the coolant and the

1 second coolant; wherein

2 the coolant as outputted from the compressor is flowed through the third heat  
3 exchanger, the third compressor, and the radiator, in that sequence, and

4 the second coolant as outputted from the second evaporator is flowed through  
5 the third heat exchanger, and the second compressor, in that sequence.

6  
7 7. A refrigerator as recited in claim 2, further comprising:

8 a third compressor for compressing the coolant as compressed by the  
9 compressor;

10 a third heat exchanger for exchanging heat between the coolant and the  
11 second coolant; and

12 a forth flow control valve for regulating the flow volume of the second coolant  
13 flowing in the third heat exchanger; wherein

14 the coolant as outputted from the compressor is flowed through the third heat  
15 exchanger, the third compressor, and the radiator, in that sequence, and

16 part of the second coolant as outputted from the condenser is flowed through  
17 the forth flow control valve, the third heat exchanger, and the second compressor, in  
18 that sequence.

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20 8. A refrigerator as recited in claim 1, wherein the heat-exchange-amount control  
21 means includes:

22 a drying-ratio estimation means for estimating, by a measured value using a  
23 predetermined sensor, a drying ratio that is a ratio between a drying rate of the  
24 coolant at the exit of the flow control valve and a drying rate when the coolant at the  
25 exit of the radiator is decompressed to its evaporation temperature;

26 a drying-ratio control-range determination means for determining a control  
27 range of the drying ratio, so that a COP value is obtained, in which the difference  
28 between the value and the maximum value obtained when the drying ratio is varied  
29 under predetermined operational conditions is within a predetermined range; and

30 a control means for controlling the amount of heat exchanged in the coolant

cooling means, so that the drying ratio estimated by the drying-ratio estimation means is within the control range.

9. A refrigerator as recited in claim 2, wherein the heat-exchange-amount control means includes:

a drying-ratio estimation means for estimating, by a measured value using a predetermined sensor, a drying ratio that is a ratio between a drying rate of the coolant at the exit of the flow control valve and a drying rate when the coolant at the exit of the radiator is decompressed to its evaporation temperature;

a drying-ratio control-range determination means for determining a control range of the drying ratio, so that a COP value is obtained, in which the difference between the value and the maximum value obtained when the drying ratio is varied under predetermined operational conditions is within a predetermined range; and

a control means for controlling the flow volume of the second coolant flowing in the coolant cooling means, so that the drying ratio estimated by the drying-ratio estimation means is within the control range.

10. A refrigerator as recited in either claim 8 or claim 9, wherein the predetermined sensor includes:

at least one of a first pressure-measuring means for measuring pressure of the coolant between the exit of the flow control valve and the entrance of the evaporator, and a first temperature-measuring means for measuring temperature of the coolant at the exit of the flow control valve;

a second pressure-measuring means for measuring pressure of the coolant between the compressor and the flow control valve;

a second temperature-measuring means for measuring temperature of the coolant at the entrance of the flow control valve; and

a third temperature-measuring means for measuring temperature of the coolant at the exit of the radiator.

1 11. A refrigerator as recited in either claim 8 or claim 9, wherein the predetermined  
2 sensor includes:

3 a first temperature-measuring means for measuring temperature of the  
4 coolant at the exit of the flow control valve;

5 a second temperature-measuring means for measuring temperature of the  
6 coolant at the entrance of the flow control valve;

7 a third temperature-measuring means for measuring temperature of the  
8 coolant at the exit of the radiator;

9 a forth temperature-measuring means for measuring temperature of the  
10 coolant at the entrance of the radiator; and

11 a fifth temperature-measuring means for measuring temperature of the  
12 coolant at the entrance of the compressor.

13  
14 12. A refrigerator as recited in claim 1, further comprising:

15 a second temperature-measuring means for measuring flow-control-valve  
16 entrance temperature as coolant temperature at the entrance of the flow control valve;  
17 wherein the heat-exchange-amount control means includes:

18 a flow-control-valve-entrance-temperature control-range determination means  
19 for determining a control range of the flow-control-valve entrance temperature, so that  
20 a COP value is obtained, in which the difference between the value and the maximum  
21 value obtained when the flow-control-valve entrance temperature is varied under  
22 predetermined operational conditions is within a predetermined range; and

23 a control means for controlling the amount of heat exchanged in the coolant  
24 cooling means, so that the coolant temperature measured by the second  
25 temperature-measuring means is within the control range.

26  
27 13. A refrigerator as recited in claim 2, further comprising:

28 a second temperature-measuring means for measuring flow-control-valve  
29 entrance temperature as coolant temperature at the entrance of the flow control valve;  
30 wherein the heat-exchange-amount control means includes:

1 a flow-control-valve-entrance-temperature control-range determination means  
2 for determining a control range of the flow-control-valve entrance temperature, so that  
3 a COP value is obtained, in which the difference between the value and the maximum  
4 value obtained when the flow-control-valve entrance temperature is varied under  
5 predetermined operational conditions is within a predetermined range; and

6 a control means for controlling the flow volume of the second coolant flowing  
7 in the coolant cooling means, so that the coolant temperature measured by the second  
8 temperature-measuring means is within the control range.

9  
10 14. A refrigerator as recited in claim 1, further comprising:

11 a third temperature-measuring means for measuring coolant temperature at  
12 the exit of the radiator; wherein the heat-exchange-amount control means includes:

13 a flow-control-valve-entrance-temperature estimation means for estimating,  
14 by the temperature measured by the third temperature-measuring means and the  
15 amount of heat exchanged in the coolant cooling means, flow-control-valve entrance  
16 temperature as coolant temperature at the entrance of the flow control valve;

17 a flow-control-valve-entrance-temperature control-range determination means  
18 for determining a control range of the flow-control-valve entrance temperature, so that  
19 a COP value is obtained, in which the difference between the value and the maximum  
20 value obtained when the flow-control-valve entrance temperature is varied under  
21 predetermined operational conditions is within a predetermined range; and

22 a control means for controlling the amount of heat exchanged in the coolant  
23 cooling means, so that the flow-control-valve entrance temperature estimated by the  
24 flow-control-valve-entrance-temperature estimation means is within the control range.

25  
26 15. A refrigerator as recited in claim 2, further comprising:

27 a third temperature-measuring means for measuring coolant temperature at  
28 the exit of the radiator; wherein the heat-exchange-amount control means includes:

29 a flow-control-valve-entrance-temperature estimation means for estimating,  
30 by the temperature measured by the third temperature-measuring means and the

1 amount of heat exchanged in the coolant cooling means, temperature at the entrance  
2 of the flow control valve as coolant temperature at the entrance of the flow control  
3 valve;

4 a flow-control-valve-entrance-temperature control-range determination means  
5 for determining a control range of the flow-control-valve entrance temperature, so that  
6 a COP value is obtained, in which the difference between the value and the maximum  
7 value obtained when the flow-control-valve entrance temperature is varied under  
8 predetermined operational conditions is within a predetermined range; and

9 a control means for controlling the flow volume of the second coolant flowing  
10 in the coolant cooling means, so that the flow-control-valve entrance temperature  
11 estimated by the flow-control-valve-entrance-temperature estimation means is within  
12 the control range.

13  
14 16. A refrigerator as recited in either claim 8 or claim 9, further comprising:

15 at least either a first pressure-measuring means for measuring pressure of the  
16 coolant between the exit of the flow control valve and the entrance of the evaporator, or  
17 a first temperature-measuring means for measuring temperature of the coolant at the  
18 exit of the flow control valve; wherein

19 the drying-ratio control-range determination means determines a control  
20 range of the drying ratio, using either the coolant pressure measured by the first  
21 pressure-measuring means or the coolant temperature measured by the first  
22 temperature-measuring means.

23  
24 17. A refrigerator as recited in either claim 8 or claim 9, further comprising:

25 a second pressure-measuring means for measuring pressure of the coolant  
26 between the exit of the radiator and the entrance of the flow control valve; wherein

27 the drying-ratio control-range determination means determines a control  
28 range of the drying ratio, using the coolant pressure measured by the second  
29 pressure-measuring means.

1 18. A refrigerator as recited in any one of claims 14 to 17, further comprising:

2 at least one of the first pressure-measuring means for measuring pressure of  
3 the coolant between the exit of the flow control valve and the entrance of the  
4 evaporator, and the first temperature-measuring means for measuring temperature of  
5 the coolant at the exit of the flow control valve; wherein

6 the flow-control-valve-entrance-temperature control-range determination  
7 means determines a control range of the temperature at the entrance of the flow  
8 control valve, using either the coolant pressure measured by the first  
9 pressure-measuring means or the coolant temperature measured by the first  
10 temperature-measuring means.

11  
12 19. A refrigerator as recited in any one of claims 14 to 17, further comprising:

13 a second pressure-measuring means for measuring pressure of the coolant  
14 between the exit of the radiator and the entrance of the flow control valve; wherein

15 the flow-control-valve-entrance-temperature control-range determination  
16 means determines a control range of the temperature at the entrance of the flow  
17 control valve, using the coolant pressure measured by the second pressure-measuring  
18 means.

19  
20 20. An air conditioner having a compressor for compressing a coolant, a four-way valve  
21 for switching the direction in which the coolant as outputted from the compressor  
22 flows, an outdoor heat exchanger for exchanging heat between the coolant and outdoor  
23 air, a flow control valve for regulating the flow volume of the coolant, and an indoor  
24 heat exchanger for exchanging heat between the coolant and indoor air, characterized  
25 in that the air conditioner includes:

26 a coolant cooling/heating means for cooling as well as heating the coolant; and  
27 a heat-exchange-amount control means for controlling the amount of heat  
28 exchanged in the coolant cooling/heating means; wherein

29 when the air conditioner is being operated for cooling, the coolant is circulated  
30 through the compressor, the outdoor heat exchanger, the coolant cooling/heating



means, the flow control valve, and the indoor heat exchanger, in that sequence, and  
when the air conditioner is being operated for warming, the coolant is  
circulated through the compressor, the indoor heat exchanger, the flow control valve,  
the coolant cooling/heating means, and the outdoor heat exchanger, in that sequence.

21. An air conditioner as recited in claim 20, utilizing a nonflammable coolant whose  
global warming potential is lower than that of chlorofluorocarbon, wherein the coolant  
cooling/heating means includes:

a second compressor for compressing a second coolant whose energy  
consumption efficiency is higher than that of the coolant;

a second four-way valve for switching the direction in which the second coolant  
as outputted from the second compressor flows;

a first heat exchanger for exchanging heat between the second coolant and  
outdoor air;

a second flow control valve for regulating the flow volume of the second  
coolant; and

a second heat exchanger for exchanging heat between the coolant and the  
second coolant; wherein

when the air conditioner is being operated for cooling, the second coolant is  
circulated through the second compressor, the first heat exchanger, the second flow  
control valve, and the second heat exchanger, in that sequence, and

when the air conditioner is being operated for warming, the second coolant is  
circulated through the second compressor, the second heat exchanger, the second flow  
control valve, and the first heat exchanger, in that sequence.

22. An air conditioner as recited in claim 20, the compressor having an  
intermediary-pressure inlet for drawing in the coolant during compressing, the air  
conditioner further comprising:

a third flow control valve for regulating the flow volume of the coolant  
inputting into and outputting from the indoor heat exchanger;

1 a gas-liquid separator for separating into gas and liquid the coolant; and  
2 a bypass pipe for introducing into the intermediary-pressure inlet part or all of  
3 the coolant gas separated by the gas-liquid separator; wherein  
4 when the air conditioner is being operated for cooling, the coolant is circulated  
5 through the flow control valve, the gas-liquid separator, the third flow control valve,  
6 and the indoor heat exchanger, in that sequence, and  
7 when the air conditioner is being operated for warming, the coolant is  
8 circulated through the indoor heat exchanger, the third flow control valve, the  
9 gas-liquid separator, and the flow control valve, in that sequence.

10  
11 23. An air conditioner as recited in claim 20, further comprising:

12 a third compressor for compressing the coolant as compressed by the  
13 compressor;

14 a third flow control valve for regulating the flow volume of the coolant  
15 inputting into and outputting from the indoor heat exchanger;

16 a gas-liquid separator for separating into gas and liquid the coolant; and

17 a bypass pipe for introducing into the third compressor part or all of the  
18 coolant gas separated by the gas-liquid separator; wherein:

19 the coolant as outputted from the third compressor is inputted into the  
20 four-way valve, and

21 when the air conditioner is being operated for cooling, the coolant is flowed  
22 through the flow control valve, the gas-liquid separator, the third flow control valve,  
23 and the indoor heat exchanger, in that sequence, meanwhile, when the air conditioner  
24 is being operated for warming, the coolant is flowed through the indoor heat exchanger,  
25 the third flow control valve, the gas-liquid separator, and the flow control valve, in that  
26 sequence.

27  
28 24. An air conditioner as recited in claim 20, further comprising:

29 a third radiator for radiating heat from the coolant as outputted from the  
30 compressor; and

1 a third compressor for compressing the coolant in a state in which heat of the  
2 coolant has been radiated away by the third radiator; and

3 a flow-route changing means for inputting into the third radiator the coolant  
4 as outputted from the compressor when the air conditioner is being operated for  
5 cooling, and for inputting into the third compressor when the air conditioner is being  
6 operated for warming.

7  
8 25. An air conditioner as recited in claim 21, further comprising:

9 a third compressor for compressing the coolant as compressed by the  
10 compressor;

11 a third heat exchanger for exchanging heat between the coolant and the  
12 second coolant; and

13 a flow-route changing means for flowing the coolant as outputted from the  
14 compressor through the third heat exchanger and the third compressor, in that  
15 sequence, when the air conditioner is being operated for cooling, and into the third  
16 compressor when the air conditioner is being operated for warming; wherein

17 the coolant as outputted from the third compressor is inputted into the  
18 four-way valve, and the second coolant as outputted from the second heat exchanger is  
19 flowed through the third heat exchanger and the second compressor, in that sequence.

20  
21 26. An air conditioner as recited in claim 21, further comprising:

22 a third compressor for compressing the coolant as compressed by the  
23 compressor;

24 a third heat exchanger for exchanging heat between the coolant and the  
25 second coolant; and

26 a forth flow control valve for regulating the flow volume of the second coolant  
27 flowing in the third heat exchanger; wherein

28 the coolant as outputted from the compressor is flowed through the third heat  
29 exchanger, the third compressor, and the four-way valve, in that sequence, and

30 part of the second coolant as outputted from the first heat exchanger is flowed

- 1 through the forth flow control valve, the third heat exchanger, and the second
- 2 compressor, in that sequence.